Crusader Titanium Gun Mount

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Crusader System Consists Of..

Future Combat Systems
FCS
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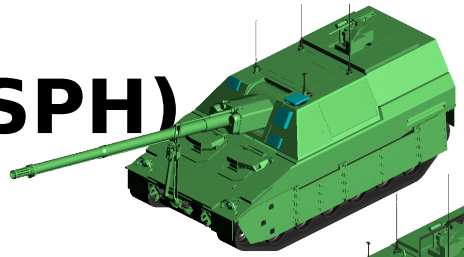
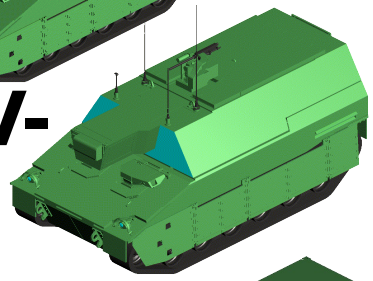
1. Self Propelled Howitzer (SPH)



2. Resupply Vehicle - Tracked (RSV-T)



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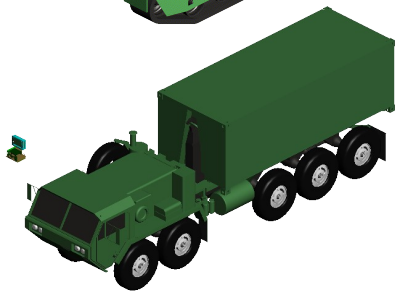

(RS

Background

- Self-Propelled 155mm howitzer Challenge: reduce from 60 ton to a 40-ton design
  - Rationale: Transport two vehicles (w/o refueling) by C5B/C17 to any part of the world for quick deployment
- Achieved Weight Reduction through:
  - Vehicle size reduction
  - Structure Optimization
  - Reduced magazine capacity
  - Lighter weight materials
    - Polymer-matrix composites
    - Magnesium
    - Titanium

Crusader SPH Gun Mount

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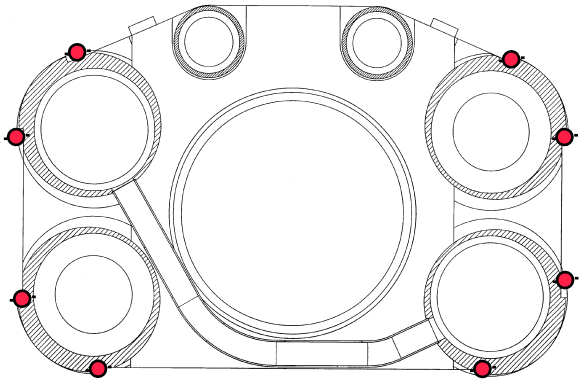
- **This presentation will focus on SPH Gun Mount Weight reduction using Titanium.**
- **Objective:**
  - **Achieve 30% weight reduction over steel w/o compromising performance**
  - **Limit cost increase to $35 per pound saved**
- **Titanium Alloy, Ti-6Al-4V:**
  - **Lighter w/ good strength & corrosion resistance**
  - **Strength-to-Weight Ratio 1.34 times that of Steel**
  - **Good Ballistic Protection**
  - **Cost of Ti-6Al-4V ~ 22 times that of Steel**

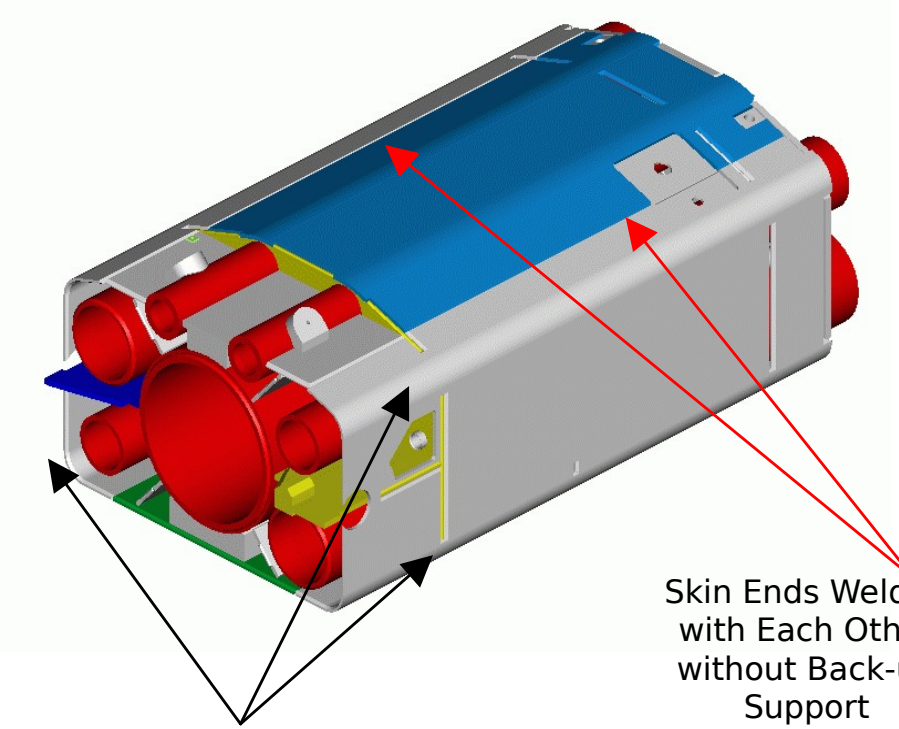
TEAM
CRUSADER

Gun Mount Cradle

- **Design Modified to Contain Cost.**
- **Minimized Skin Formation:**
  - **Simplified skin design as opposed to wrap around plate as used in the steel cradle**
- **Welding:**
  - **Weld onto the notches in eccentric tubes for backup support.**

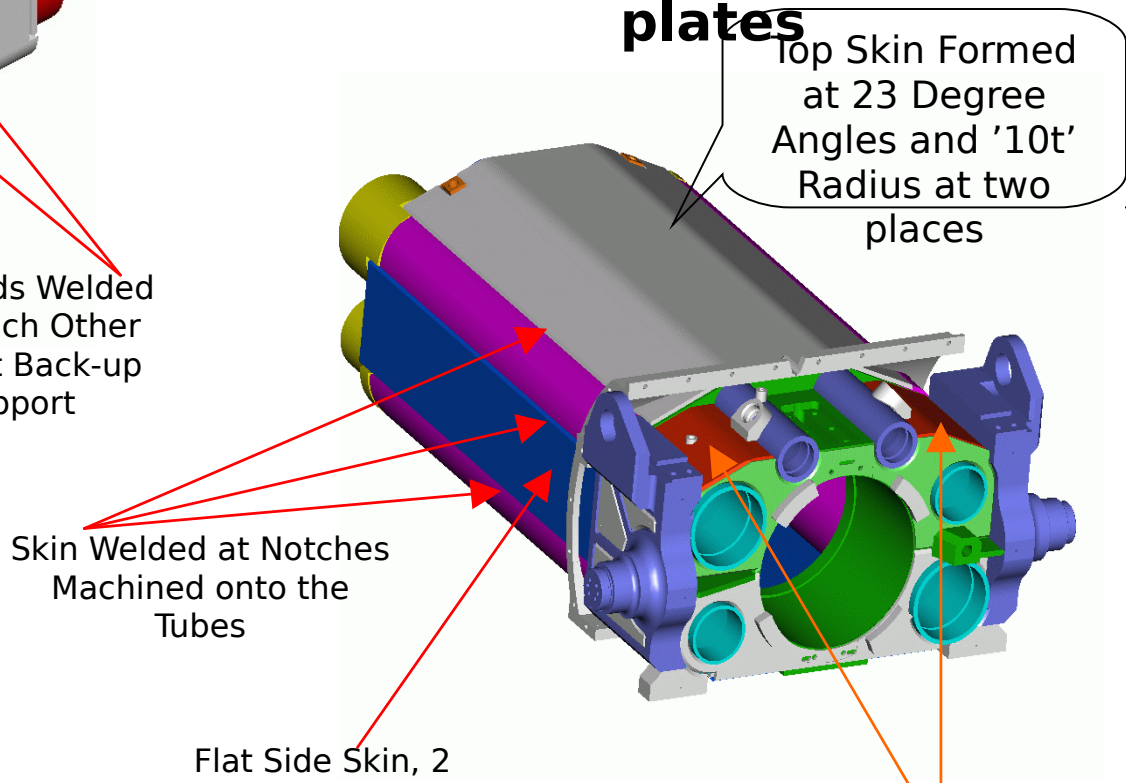


Titanium Versus Steel Design



Steel Cradle: Severe forming of skin plates and welding the skin plates without back-up support

Titanium Cradle: Simplified forming and welding of skin plates


Top Skin Formed at 23 Degree Angles and ’10t’ Radius at two places
Skin Welded at Notches Machined onto the Tubes
Flat Side Skin, 2 places
Two Small Plates Formed at 23 degree Angles, and ’10t’

SPH Cradle -- Titanium

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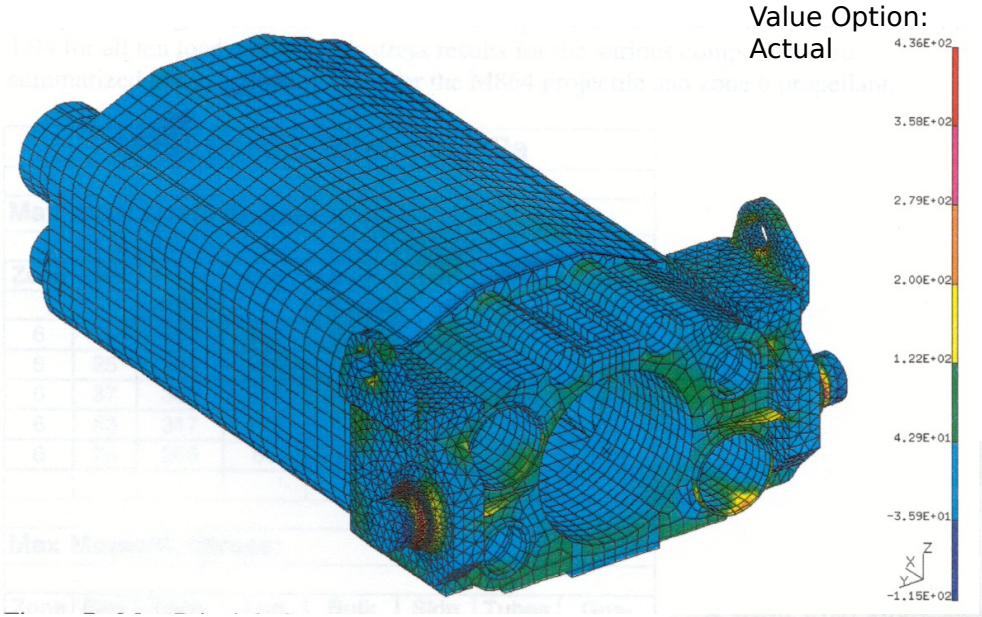
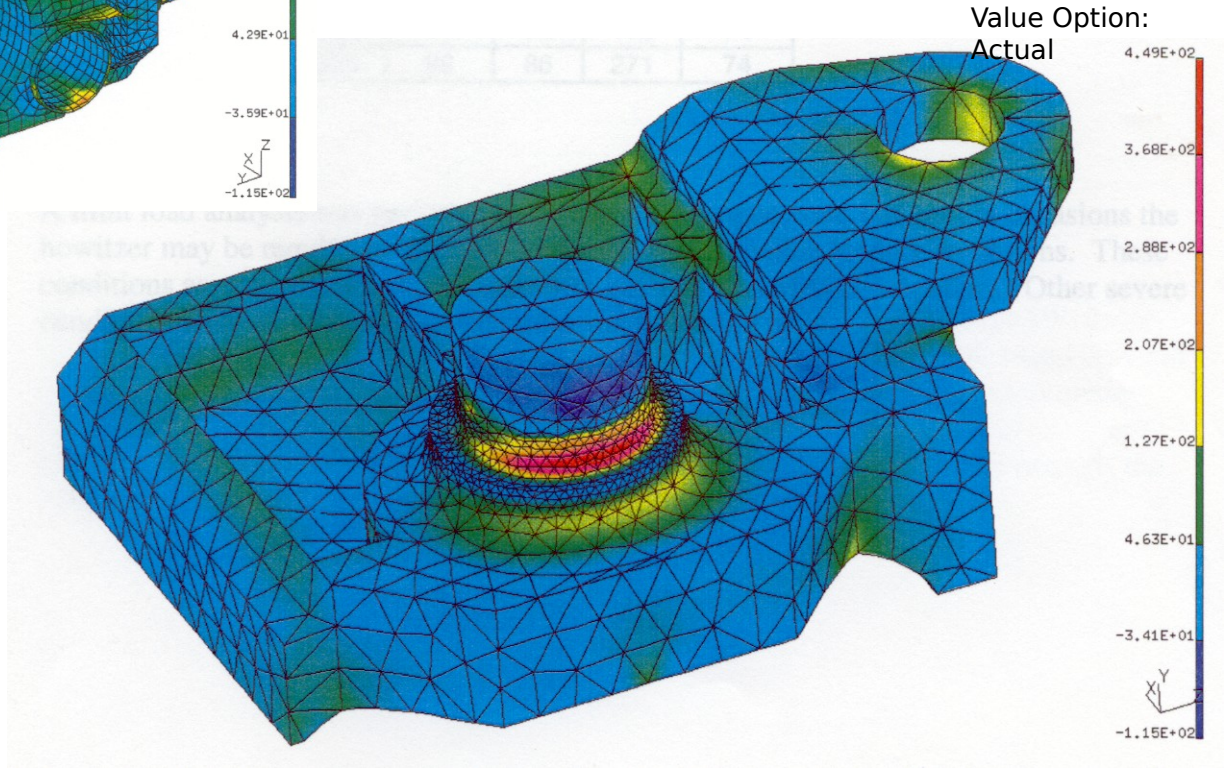


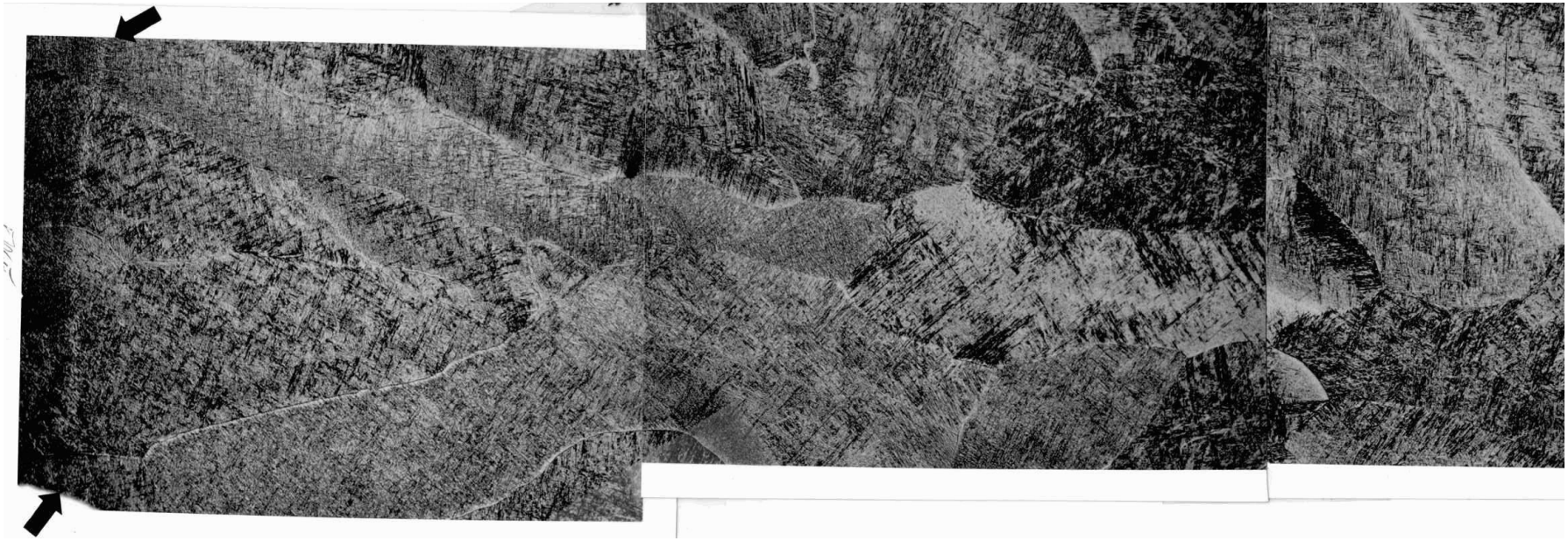
Max Principle Stress Contour

0 Deg Elevation, Max Axial Load



Welding of Titanium

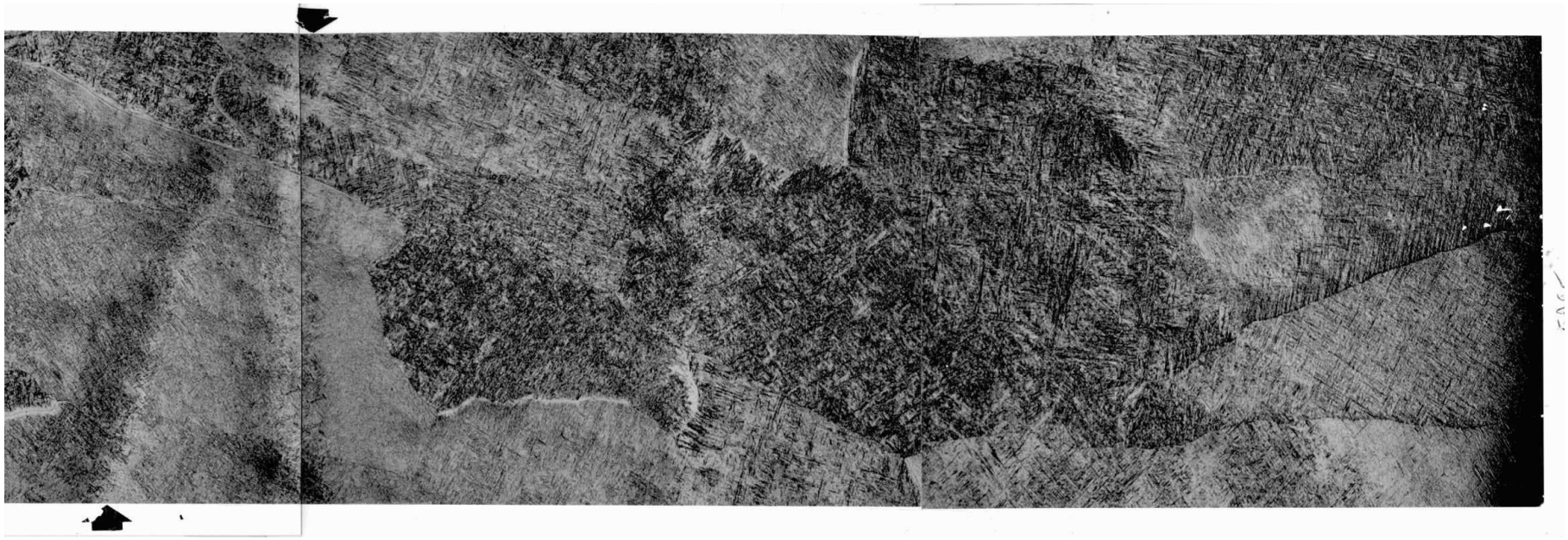
- Cost further contained through low cost Gas Metal Arc Welding (GMAW or MIG) in pulsed spray transfer mode with no trailing gas shielding



Microstructure of the Weldment and Heat Affected Zone (HAZ) at 50x; Alpha phase is light, Beta phase is dark

Welding of Titanium (continued)

- Gas Tungsten Arc Welding (GTAW) limited to some root passes and where accessibility is difficult



Microstructure of the Weldment and Heat Affected Zone (HAZ) at 50x; Alpha phase is light, Beta phase is dark

Welding Parameters

- **Filler Material Specifications AWS A-5.16**
- **Type: ERTi-5ELI**
- **Filler Size: 0.045”**
- **Gas Cup Size: ¾ “**
- **Current Type & Polarity: DCEP (pulsed)**

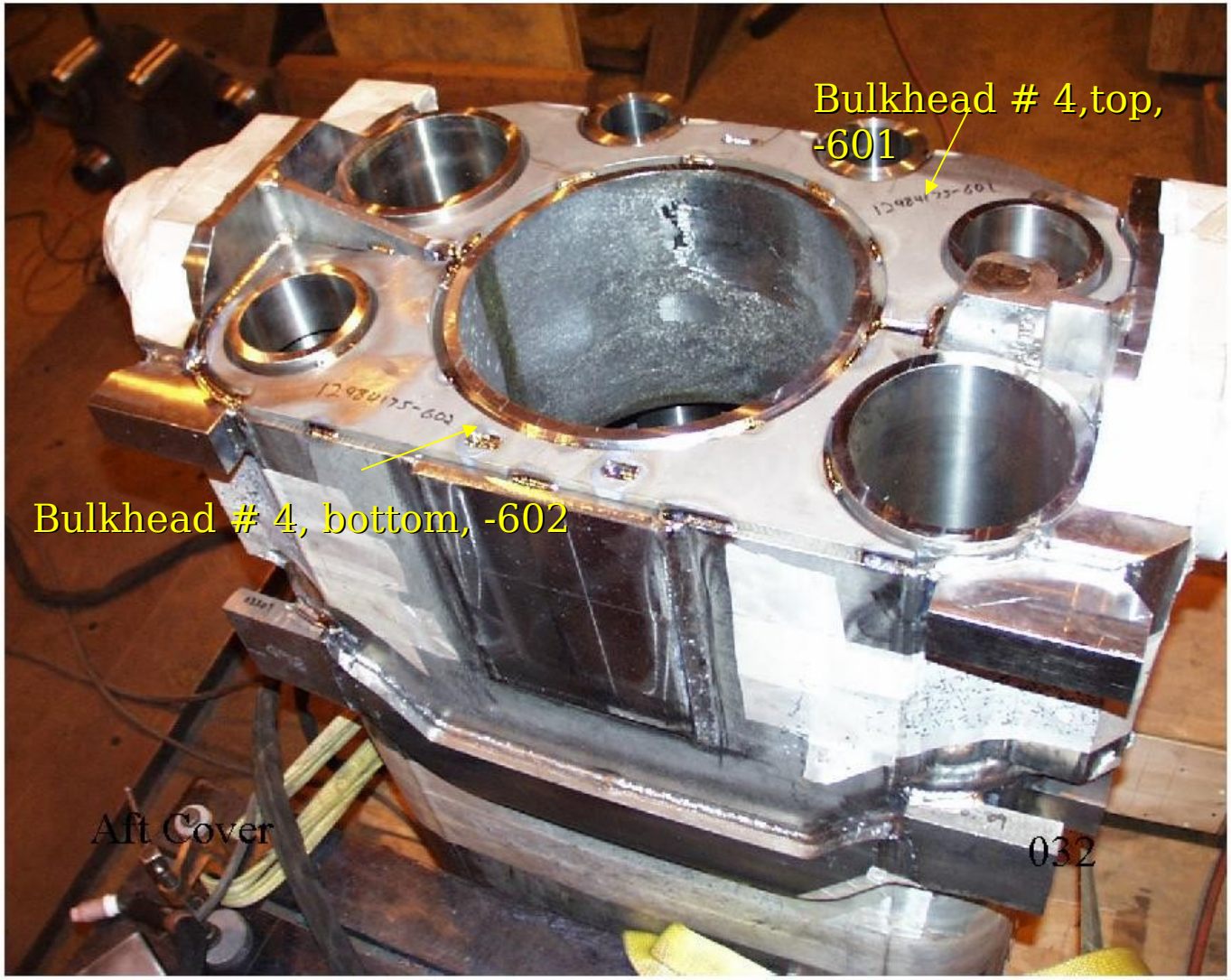
Pass Type	Arc Voltage (volts)	Welding Current (Amperes)	Travel Speed (rpm)	Shielding Gas	Flow Rate cfh	Preheat (min °F)	Interpass (Max °F)
1st root	22.3 – 28.0	150 – 250	13.5 – 27.5	Argon	22 - 35	50	N/A
Remaining passes	22.3 – 28.0	150 – 250	13.5 – 27.5	Argon	22 - 35	50	250

Weld Properties

- Average of 6 MIG and 6 TIG tensile specimens

Sample	Yield	Ultimate	Elongation
TIG	127	143	11.0%
MIG	124	140	9.6%

Gun Mount Cradle Top & Bottom Bulkhead #4 Welding



MANTECH Titanium Cradle -- Actual Weight

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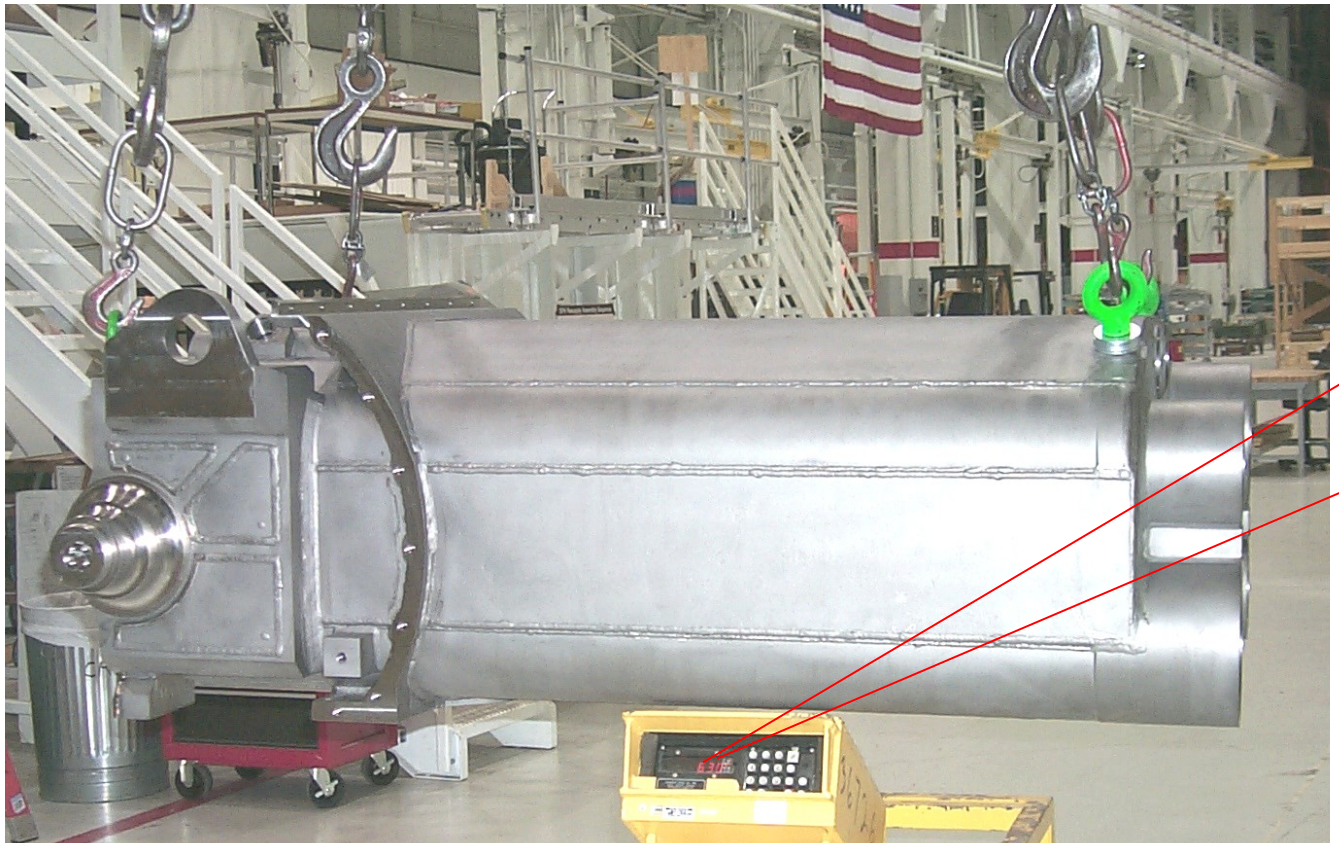
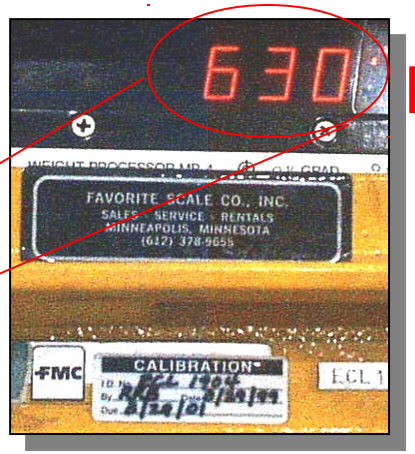


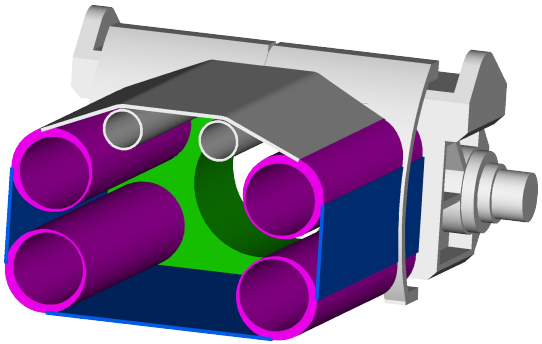


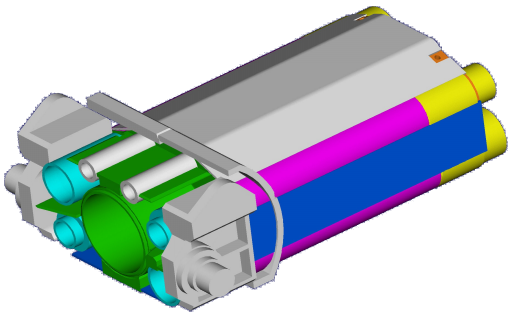
Weight Reduction from Steel Design: 284 Kg (31%)

Production Cost = $200K ------ Tested on Crusader

Crusader Gun Mount Cradle in Titanium

- 31% Weight Reduction achieved over steel. Cost increase of $35 per pound saved.
- Cost contained through low cost welding (Gas Metal Arc Welding) & welding of cover plate to tubes (vs complete wrap-around design).
- Gas Tungsten Arc Welding limited to some root passes where accessibility difficult
- Gun Mount successfully tested in simulation and actual firing meeting performance.





Other Titanium Applications

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Other Titanium Application on Crusader

- Engine Door – SPH & RSV
  - Alternate Approach: Use Single-melt Titanium Electron Beam Single Melt
- Lifting and Tie-Down Eyes
- Jounce Stops
- Power pack Inlet Grilles
- NBC / ECU Inlet Grilles
- Tool Hood Ballistic Shield
- Rear and Front Corner Braces
- NBC Inlet Grilles

Titanium Technology will be transitioned to FCS

Alternate Approach: Ballistic & Mechanical Properties of Single Melt

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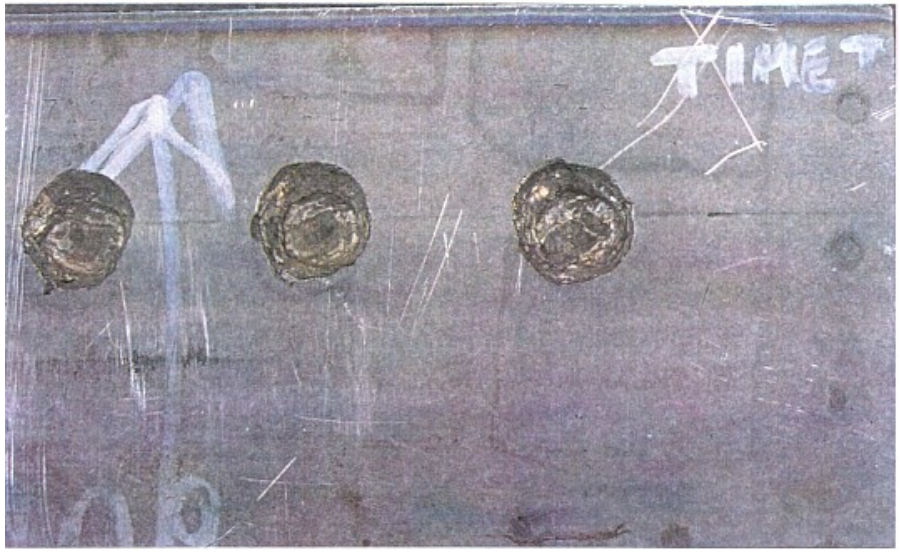
Thickness		Material	Test Projectile	Test V50		Expected V50*	
mm	in			m/s	f/s	m/s	f/s
25.35	1	EB Single Melt	20mm FSP	1016	3332	950	3116
26.72	1	Standard	20mm FSP	1023	3355	1008	3306
38.79	1.5	EB Single Melt	20mm FSP	1493	4897	1362	4467
38.30	1.5	Standard	20mm FSP	1496	4907	1352	4435
63.96	2.5	EB Single Melt	30mm APDS	932	3057	889	2916
63.83	2.5	Standard	30mm APDS	941	3086	888	2913

* from MIL-DTL-46077F

Thickness		Orientation	Tensile Strength		Yield Strength		Elongation	Red. Of Area
ins	mm		ksi	MPa	ksi	MPa	%	%
0.97	25	L	145	999	134	923	13	21
0.97	25	T	149	1027	138	951	15	24
1.5	38	L	142	978	132	909	12	22
1.5	38	T	144	992	135	930	13	23
2.5	64	L	138	951	128	882	13	24
2.5	64	T	140	965	132	909	13	25
MIL-T-9046 Spec Min:			130	896	120	827	10	

Impact Locations
25mm EBCHM Plate



Front

Close-up Photographs of Impact Locations on the 25-mm (0.97 in) EBCHM Plate

Rear

Impact Locations
38mm EBCHM Plate

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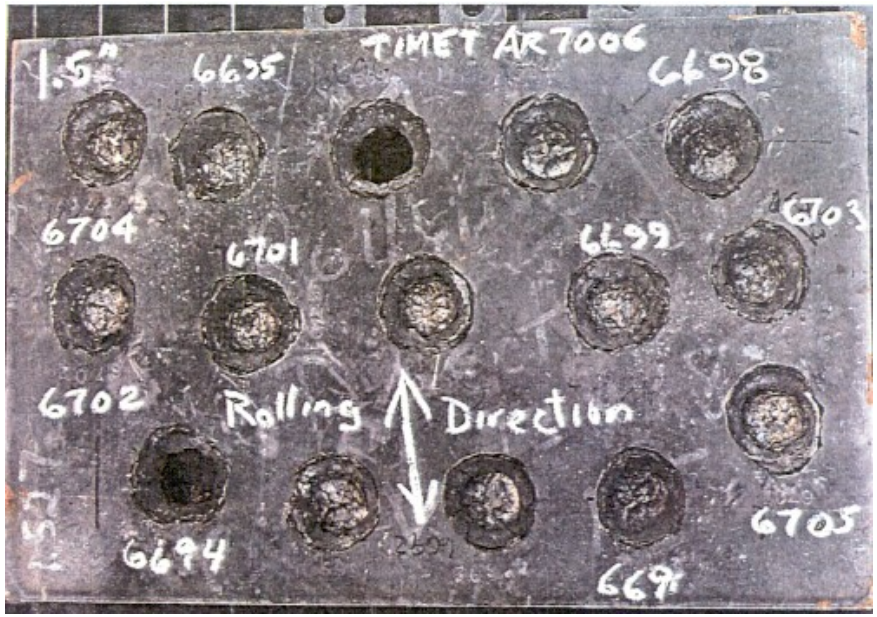
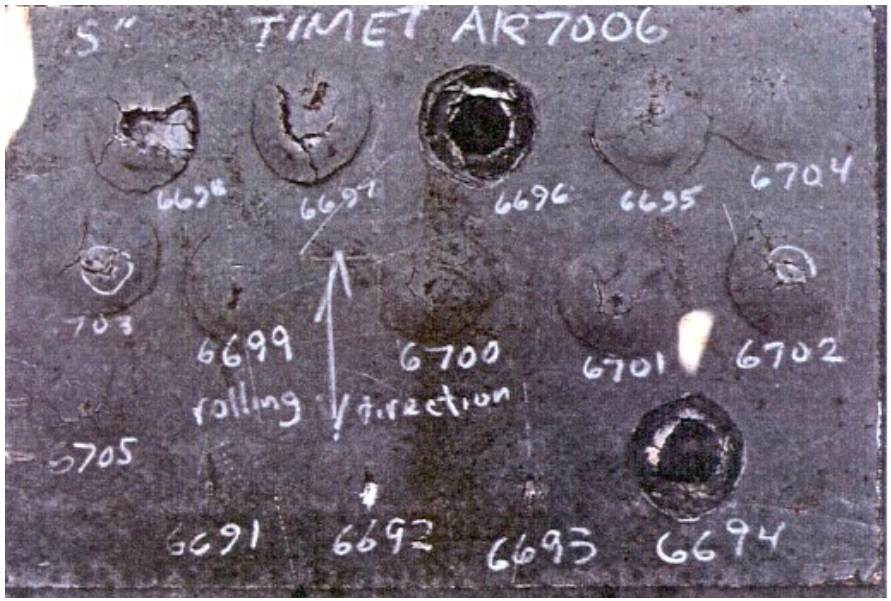


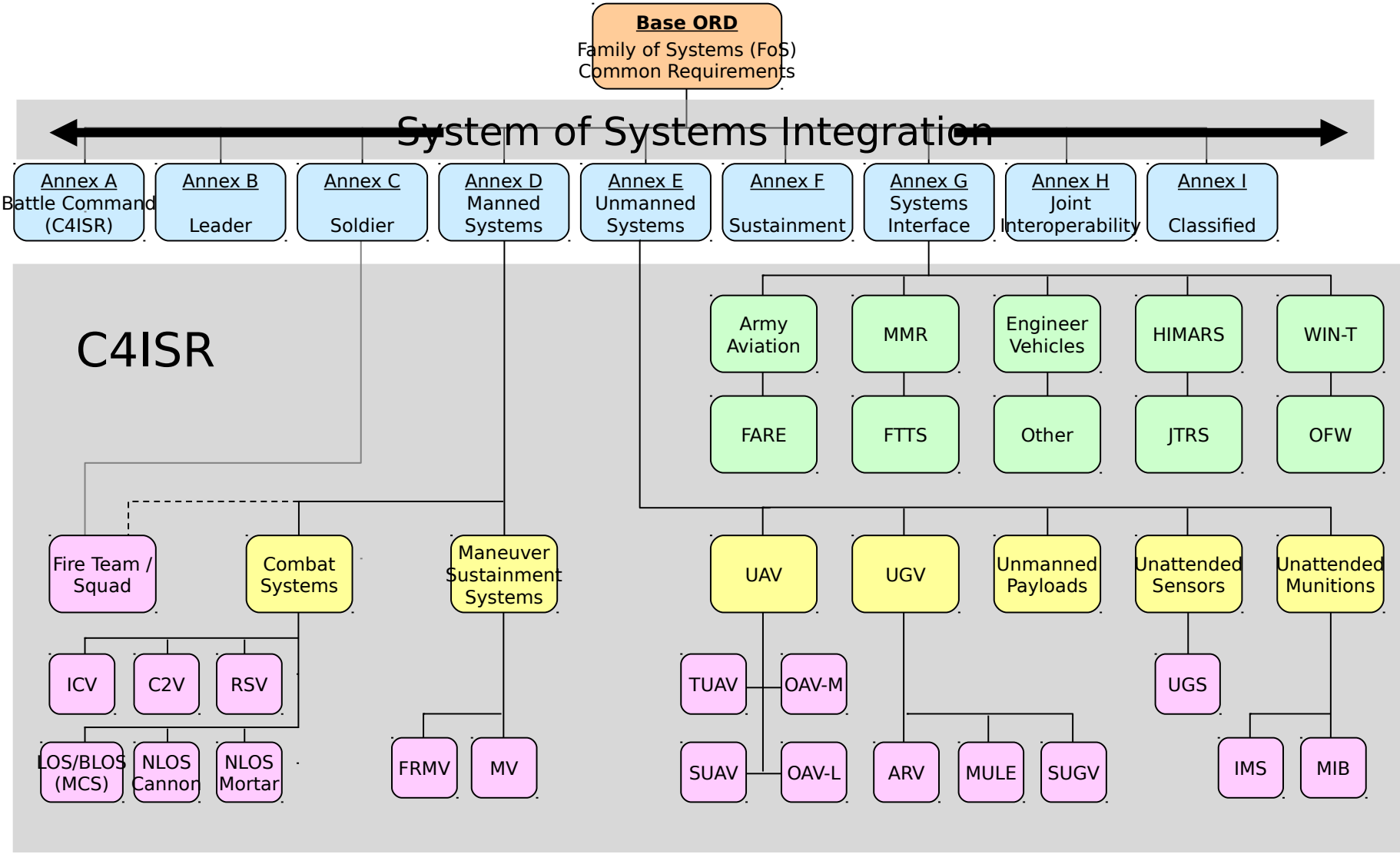
Front

Photographs of 38-mm (1.5 in) EBCHM Plate After Ballistic Testing

Rear



FCS System of Systems



Future Combat Systems

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■ Manned Systems

ICV

C2V

Mounted Combat System

Reconnaissance and Surveillance

■ Unmanned Aerial System

Class III

Class II
Class I

Class IV

■ Unmanned Ground Vehicles

Small Manpackable UGV (TBD)

Armed Robotic Vehicle

Mule

Unmanned Payloads

Unattended Ground Sensors

Unattended Munitions
-NLOS LS
-Intelligent Munitions

NLOS Cannon

NLOS mortar

FCS Maintenance and Recovery Vehicle

Medical Treatment, Evacuation

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Summary

- There is a need within the Army to reduce weight of vehicles and systems
  - For air transportability
  - For quick deployment
- In the past, the Army was willing to pay up to $35 for every pound saved
- Currently, the Army is willing to pay up to $100 for every pound saved
- As part of the transformation to quick deployment objective force, the Army is looking at a spectrum of science and technologies including light weight materials and composites for Future Combat System.